

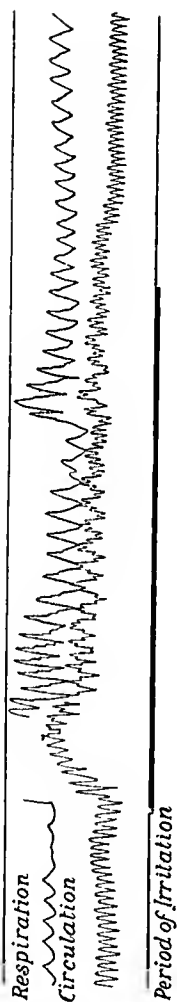
ON THE INFLUENCE OF ANÆSTHESIA ON THE
EFFECT PRODUCED ON THE CIRCULA-
TION AND RESPIRATION BY IRRI-
TATION OF A SENSORY
NERVE.

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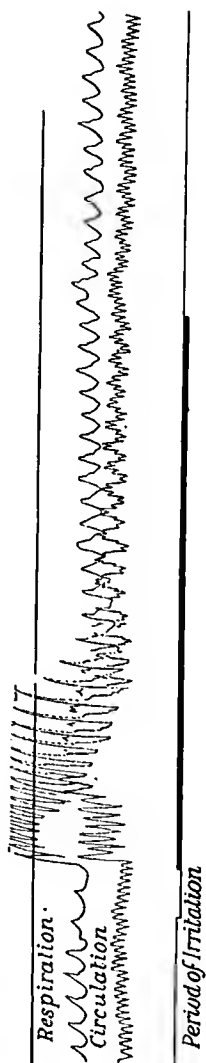
DURING the past three years the writer has been engaged in an investigation of the nature of shock. In the course of these experiments, certain phenomena concerning the influence of anæsthesia on the effect produced on the circulatory and respiratory apparatus by irritation of the sensory nerves have been observed that seemed worthy of some special notice.

The effect of irritation of sensory nerves on the circulation and the respiration is a matter upon which physiologists have held various opinions. Bezold ("Untersuchungen über die Inervation des Herzen's," page 272; Hermann's "Handbuch der Physiologie," Vol. iv, page 392) found that irritation of sensory nerves (sciatic, brachial, and spinal nerves, skin), after section of both vagi and sympathetic in curarized dogs and rabbits, produced an increase in the frequency of the pulse-rate and a rise in blood-pressure. This occurred only if the brain and cord were intact. If the medulla was severed, either from the brain or cord, this did not occur.

Lovén (*Berichte d. Sachs. Ges. d. Wiss.*, 1866, page 85) found that if the vagi were divided, irritation of sensory nerves produced either no change in the pulse-rate, or else the rate was diminished. Asp (*Idem.*, 1867, page 182) obtained after irritation of the central end of the divided ischiatic plexus or of the lumbar or dorsal cord, an increase in the frequency of the pulse both before and after section of the vagi. Hering and



TRACING I.



TRACING II.

Kratchmer (Sitzungs Bericht d. Wiener Acad., lxii, 2, page 147, 1870) irritated the nasal mucosa membrane with tobacco smoke and other gases, and stimulated the supramaxillary branch of the fifth; if the vagi were intact, a slowing of the heart with little or no rise in blood-pressure was produced. If the vagi were divided, no change in the pulse-rate followed. As a rule, it was found that irritation of a sensory nerve produced a rise in blood-pressure. Gad ("Physiol. d. Menschen," page 372) states that probably every painful irritation of a sensory nerve produces a dilatation of the vessels of the skin locally, and a contraction of the vessels generally, as is evidenced by a rise in blood-pressure. We shall see as the result of my own experiments that the element of pain is a very considerable factor in determining the effect of such irritation on the general blood-pressure.

Latchenberger and De Alna (*Arch. für d. Ges. Physiol.*, xii, page 157, 1876) found that continued irritation of a sensory nerve did not bring on a continuous rise in blood-pressure. After a few minutes the pressure sinks until it gradually regains the pressure that existed before irritation of the nerve. If the irritation was kept up for many minutes or an hour with frequent interruptions, there was produced a sinking of the blood-pressure during the time of the irritation. This effect was produced sooner in animals that had had their cerebra removed.

R. Hunt (*Journal of Physiology*, xviii, 5 and 6, page 381) found that irritation of a sensory nerve produced sometimes an increase and sometimes a fall in blood-pressure. On the supposition that this difference in result might be due to the preponderance of pressor or depressor nerve fibres, his experiments were conducted in such a way as to eliminate one of these varieties of hypothetical fibres. He found that after section of a centripetal nerve the depressor fibres were regenerated earlier, so that central irritation of a recently regenerated nerve was always followed by a fall in blood-pressure. A similar result was obtained by refrigeration of the nerve; *i.e.*, the depressor fibres remained longest intact.

Seconds

Respiration



Circulation



Period of Irritation

TRACING III.

The effect upon the respiration produced by irritation of a sensory nerve has been even more variously described by different experimenters. Schiff (*Molescott Untersuch.*, viii, page 313) found that mild irritation of sensory nerves produced a slowing of respiration, and at times even a temporary cessation in expiration. Rosenthal (Herrmann's "Handbuch d. Physiologie," Vol. iv, Part II, page 252), with electrical stimulation of the crural nerve in unanesthetized animals, observed violent inspiration and expiration; in narcotized animals, no appreciable effect.

Langendorff (V. Wittich's *Mittheil. ad. Königsberger Physiol. Lab.*, 1878, page 33) found that mild stimulation of a sensory nerve had an inspiratory effect, stronger stimuli, an expiratory.

In deeply narcotized animals, and in animals in whom the cerebrum had been removed, he often observed an increase in the rhythm, oftener a mild inspiratory tetanus; if the irritation were kept up a longer time, or if it were increased, a slowing of the rhythm followed. It is very probable that the variation in the effect observed is largely due to the varying state of narcosis present. The effect of irritation of a sensory nerve in all probability passes through the cerebrum, and the condition of the cells of the cortex would have a great modifying influence on the effect that would follow on the respiration and circulation.

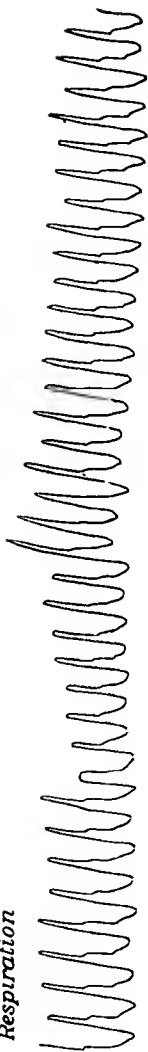
METHOD OF INVESTIGATION.

Anæsthesia.—The animals used were dogs, and when anæsthesia was used, ether was invariably employed. During the experiment, the ether was administered through the tracheal tube.

Record of Circulation.—The blood-pressure and cardiac contractions were recorded by means of a mercurial manometer connected with the right carotid artery.

Record of Respiration.—The movements of the thorax were recorded by means of a Paul Bert exploring tanhous attached to a strap of adhesive plaster which encircled the lower

Respiration



Circulation



Period of Irritation



TRACING IV.

portion of the chest. This tambour was connected by means of a rubber tube with a Marey tambour, whose writing lever thus recorded the movements of expansion and contraction of the chest. The up stroke represents the inspiratory movement; the down stroke, the expiratory.

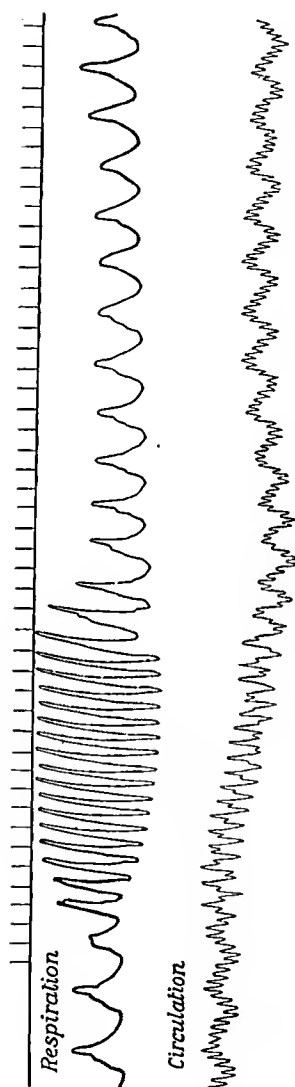
Record of Time.—The time was recorded by means of a metronome beating seconds, placed in circuit with an electric signal, thus transmitting its rhythm to the signal, which marked the time on the paper of the kymograph.

Record of the Time of Stimulation of the Nerve.—In all experiments, the right crural nerve was divided and the central end stimulated electrically. For this purpose a Du Bois Reymond apparatus with platinum electrodes was used. The separation of the primary and secondary coils is given in each case. An electric signal was placed in the primary circuit of the apparatus, so that the time during which the nerve was irritated was marked on the paper of the kymograph. In all, twenty dogs were used. Many experiments were made on the same animals in various stages of anæsthesia. In only one dog was no anæsthetic employed. The results here were constant and have been described before, so that I did not deem it justifiable to repeat this experiment.

Phenomena observed in Unanæsthetized Animals.—Stimulation of the central end of the crural nerve in an animal that had received no narcotic always produced the same effect. The respiration was increased in frequency about 50 per cent., and the inspiratory effort was markedly increased.

The cardiac rhythm was also increased approximately to the same extent. The blood-pressure invariably rose. These effects gradually disappeared after the cessation of the stimulation, so that about one minute thereafter the respiratory rhythm and force were as before, and the same was true of the circulatory apparatus.

Tracing I was obtained from a typical experiment of this kind. The coils of the faradic apparatus were ten centimetres apart. The stimulation occupied a period of forty-three seconds. The respiration was markedly increased in force and in



TRACING V.

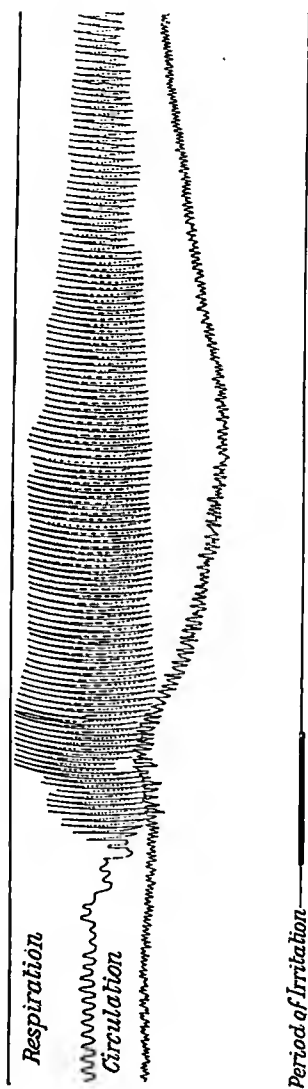
rhythm—from 32 per minute to 48 per minute; the cardiac contraction from 92 per minute to 104 per minute. The greatest rise in blood-pressure was 44 millimetres.

Tracing II is from a similar experiment in which the effect on the respiration is even more marked. It will be seen in these tracings that the effect is greatest at the beginning of the irritation. When this is kept up for some time the effect wears off, so that after thirty or forty seconds it is scarcely appreciable. This corresponds with the observation of Latchenberger and de Ahna.

Effect on Narcotized Animals.—If the animals were deeply anæsthetized with ether so that there was absolutely no corneal reflex, the result was very different. In most instances the irritation of the central end of the crural was without effect either upon the circulation or respiration.

Tracing III shows such an experiment. The nerve was stimulated with the faradic coils ten cubic centimetres apart, and the circulatory and respiratory curves are unchanged. At other times there is a very slight effect on the respiration in that the inspiration is slightly inhibited. The rhythm remains unchanged and the circulation is not disturbed. This is very well shown in *Tracing IV*. From this it may be seen that the effect of irritation of the sensory nerve depends in a very great measure on the condition of the sensorium. If this is completely paralyzed, we have practically no effect; if it is unnarcotized, we have the effect seen in the first series of experiments.

On the other hand there is a condition of the sensorium between these two which very materially alters the effect. If the animal is anæsthetized, but only partially, so that there is a condition of semianæsthesia in which the corneal reflex is present, but in which the animal lies quietly on the table, then we have a very different effect. In such animals the respiration, just as in the unnarcotized animals, becomes greatly accelerated in rhythm and increased in amplitude. On the part of the circulatory apparatus, a very different result is observed. Instead of an increase in the pulse-rate and a rise in pressure



TRACING VI.

as occurred in unnarcotized animals, we have a marked fall in blood-pressure. This fall begins a few seconds after the beginning of the irritation of the nerve, lasts for a varying number of seconds, and eventually returns to the level present before the irritation. It may be preceded by a slight rise, probably due to the increase in the force of the cardiac contractions.

Tracing V shows such an experiment. The corneal reflex was present, and the coils of the faradic apparatus were ten centimetres apart and the nerve was irritated for fourteen seconds.

In *Tracing VI* this "vasomotor shock," for so it may be termed, is much more marked.

The stimulus was much stronger here, the coils being five centimetres apart.

In every experiment there was a stage of narcotization at which the irritation of the central end of the erural nerve produced this fall in blood-pressure.

The conclusion may be drawn from these experiments that severe vasomotor shock is more liable to follow operations done under partial anæsthesia than such as are done under complete insensibility.